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(54)名稱：由混合之廢料中將紙纖維及塑膠分開之方法及裝置及其所得產物

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[57]申請專利範圍：

1. 一種由包含紙纖維、塑膠和金屬或無金屬之來源的混合廢料中分離紙纖維的方法，該方法包括在水碎漿機中，在水之存在下將該混合廢料攪拌至形成包含紙纖維部份和塑膠及金屬部份的漿體，其特徵爲：由漿體抽取水及塑膠和任何金屬及相當量紙纖維部份離開水碎漿機，而形成一液體流；由液體流(Liquid stream)移除塑膠和任何金屬，產生富含紙纖維流，接著，由富含纖維流中，去除輕污染物，而獲得濕紙纖維。
2. 根據申請專利範圍第1項之方法，其中富紙纖維流首先在第一離心分離機處理，以自富含紙纖維流分離重的污染物，然後在第二離心分離機處理，以自富含紙纖維流分離輕的污染物。
3. 根據申請專利範圍第1或2項的方法，此方法包括使富含紙纖維流通過浮選槽，以在壓縮步驟之前自富含紙纖維流分離油墨粒子之額外步驟。
4. 根據申請專利範圍第1項之方法，其中由液體流移除塑膠和任何金屬是藉由使該液體流順序通過粗篩網和有槽篩網來達成。

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5. 根據申請專利範圍第1項之方法，此方法包括將移除之塑膠和金屬組份移至研磨碎機；在研磨機將塑膠和金屬組份磨碎；在研磨步驟之後將金屬成份與塑膠成份分離；將分離步驟所得之塑膠組份乾燥；將乾的塑膠組份供應至擠壓機；及將塑膠組份擠壓。
6. 根據申請專利範圍第5項之方法，其中該分離步驟包括將塑膠和金屬組份供應至沉降槽，並令較緻密組份沉降而塑膠組份隨著水流移除。
7. 根據申請專利範圍第5項之方法，此方法包括在塑膠組份供應至該擠壓機之前將乾燥塑膠組份粉碎。
8. 根據申請專利範圍第2項之方法，此方法包括在該第一分離機和該第二分離機之間保持大約10和30psi之壓力差，以使液流由第一分離機流至第二分離機。

9.根據申請專利範圍第4項之方法，其中該有槽篩網之槽寬度介於大約0.004和 0.010英吋之間，而通過有槽篩網之富含纖維流含有至少99%水。

10.一種根據申請專利範圍第1項之方法所產生之再回收紙纖維。

11.一種根據申請專利範圍第1項之方法製造、含有介於大約10%和大約30%再回收紙纖維之紙板，其紙漿與造紙工業技術學會(TAPPI)污物含量低於大約80。

12.一種進行申請專利範圍第1項之方法之裝置，該裝置包括用以在水之存在下將混合廢料攪拌，以形成包括紙纖維部份和非紙纖維固體部份之漿體的室；用以由漿體分離相當量紙纖維部份以形成富含含紙纖維流的抽取配備；一用以由該抽取配備將該液流引至紙漿排出出口之導管；在該出口和抽取配備之間，用以分離該液流中塑膠和金屬組份與紙纖維之篩網；介於該篩網和排出出口用以由富含紙纖維流中分離重的污染物之第一離心分離機；以及介於第一離心分離機和排出口間用以由富含紙纖維流中移除輕污染

物，以獲得濕紙紙纖維漿之第二離心分離機。

13.根據申請專利範圍第12項之裝置，此裝置包括，用以將塑膠和金屬組份自室和自篩網移送至研磨碎機站之移送裝備；用以擠壓塑膠之塑膠擠壓機，該移送配備包括將該組份由該研磨機移至擠壓機之裝置。

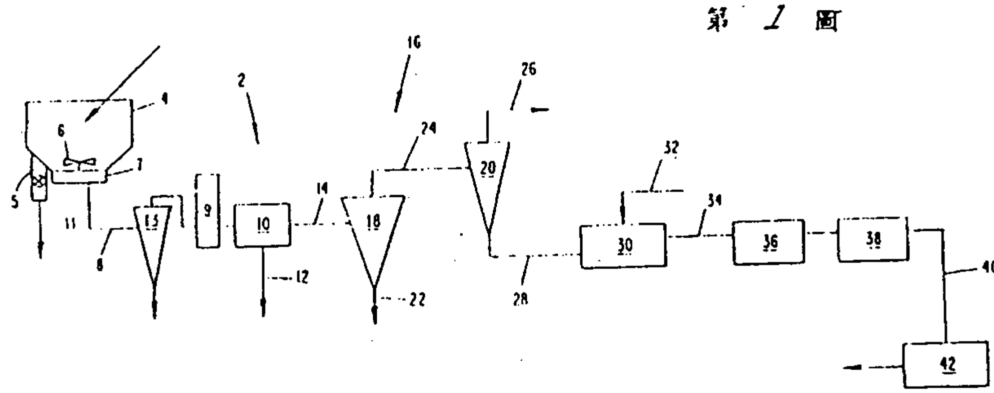
14.根據申請專利範圍第13項之裝置，此裝置包括用以在移送至擠壓機之前將塑膠和金屬組份粉碎之粉碎裝置。

圖示簡單說明：

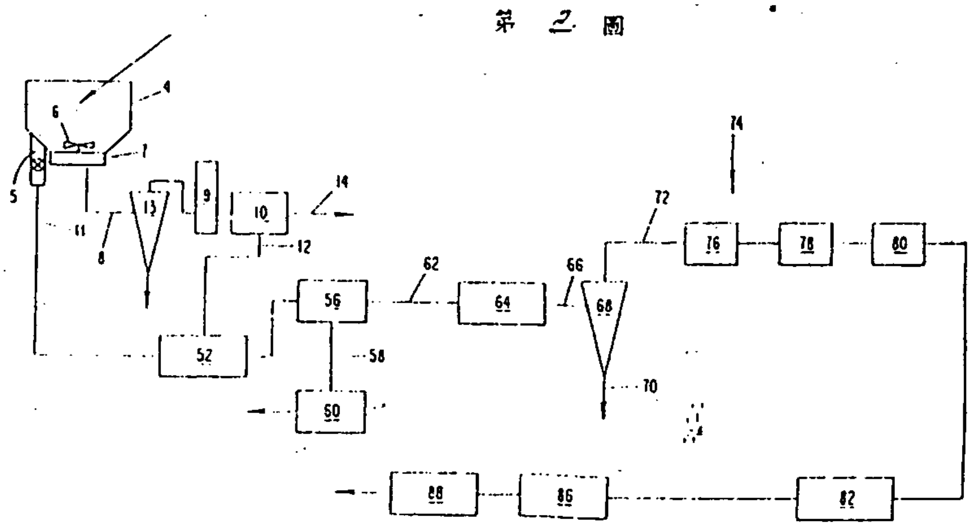
圖1是本發明用於由混合廢料分離紙纖維和回收實質純紙纖維的具體例的概略圖；及

圖2是本發明用於處理塑膠和塑膠／金屬複合物之混合物以回收實質純，可再回收品質(意指該塑膠部份可以使用在薄膜形成用途，而紙纖維可以再製成高品質最終用途)之塑膠和紙纖維之另一具體例之概略圖。同時回收之塑膠／金屬複合物含有足夠高份量的金屬(例如，20%鋁)適合使用於回收金屬之方法中。

第 1 圖



第 2 圖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ABSTRACT

A method of separating paper fiber from mixed waste materials which contain sources of paper fiber, plastic with or without metal, said method including agitating the mixed waste materials in the presence of water in a hydrapulper to form a slurry comprised of a paper-fiber portion and a plastic and metal portion, characterized by extracting water and plastic and any metal and a substantial amount of the paper-fiber portion from the slurry out of the hydrapulper to form a liquid stream; removing plastic and any metal from the liquid stream to produce a paper fiber-enriched stream; and subsequently removing light contaminants from the fiber-enriched stream to thereby obtain wet paper fiber.

METHOD AND APPARATUS FOR SEPARATING PAPER FIBER AND PLASTICS FROM MIXED WASTE MATERIALS AND PRODUCTS OBTAINED THEREBY

FIELD OF THE INVENTION

The present invention is generally directed to a method and apparatus for separating paper fiber from mixed waste materials which contain one or more sources of paper fiber, such as corrugated cartons, newspapers, magazines, cardboard, beverage containers and the like, in order to obtain substantially pure paper fiber which can readily be recycled to high grade ends uses such as for paperboard having, e.g., high brightness and low dirt content, as opposed to low grade end uses, such as for tissue paper. Preferably, the substantially pure paper fiber can be recycled into high grade end use products such as laminated paperboard products.

The present invention is also generally directed to a method and apparatus for separating plastic and/or plastic/metal composites from mixed waste materials which contain one or more sources of plastic and/or plastic/metal composites, such as milk containers, gable-top cartons, aseptic packages, and the like, in order to obtain substantially pure plastic which can be readily recycled to high grade end uses which call for plastic having, e.g., the ability to be blow-molded or the ability to be extruded into thin films, as opposed to low grade end uses such as plastic lumber, and/or in order to obtain plastic/metal composites which have a sufficiently high metal content to be suitable for use in the economical recovery of the pure metal. Preferably, the substantially pure plastic can be recycled into high grade end uses such as laminated paperboard products.

The source of plastic and/or plastic/metal composite may also contain, and often does contain, an amount of paper fiber, and the present invention is further generally directed to a method and apparatus for recovering this paper fiber in substantially pure form in order to provide additional recyclable paper fiber which can be readily recycled, also preferably to high grade end uses such as laminated paperboard products.

BACKGROUND OF THE INVENTION

Various methods are known for recycling waste which contains paper and/or plastic.

For example, Brooks, United States Patent No. 3,741,863, discloses a method of separating and recycling cellulose fibers from waste by heating and abrading the cellulose material and then softening any resins contained therein. The separated fibers are then combined with a resin to form a mat which is compressed to form a board.

Laundrie, United States Patent No. 3,814,240, discloses a method of separating waste paper from a thermoplastic film using a hot gas stream to contract the plastic and make it easier to mechanically remove the plastic particles.

Marsh, United States Patent No. 3,925,150, describes a method of separating waste corrugated paperboard into neutral sulfite semi-chemical pulp and short fiber constituents. The waste is processed through two pulpers with a liquid cyclone and screening stage in between.

Trä, United States Patent No. 4,017,033, addresses the problem of separating heavy and light contaminants from partially liberated fibrous materials. A centrifugal separator is used to create a high speed vortex which allows the heavy contaminants to be removed as a bottoms. A further separation means is used to remove the light contaminants.

Ortner et al., United States Patent No. 4,231,526, disclose the treatment of waste paper to separate both light and heavy foreign matter. The light foreign matter is sent to a hydrocyclone from which the recovered fibers are sent to a storage facility.

Espenmiller, United States Patent No. 4,272,315, discloses a process of recovering fiber from waste paper by continuously removing plastic and lightweight trash. The pulper is equipped with different sized extraction holes to facilitate separation.

Heinbockel et al., United States Patent No. 4,283,275, disclose an auxiliary circulation system comprising a stock

pulper equipped with a rotor and two screens having different sizes of mesh for the removal of contaminants from a stock suspension. Means are included to channel the stock suspension to a papermaking machine and to provide an auxiliary circuit for the removal of contaminants and rejects such as plastics and foils.

Cerroni, United States Patent No. 4,314,674, discloses a method of separating an urban waste mixture of paper and plastic. The waste is initially separated and then a mix of paper and plastic film is ground such that the size of the paper is reduced without affecting the size of the plastic.

Zentgraf et al., United States Patent No. 4,570,861, disclose a method of separating paper and plastic by comminuting the mixture, triboelectrically charging the comminuted mixture and then letting the mixture pass through a free-fall separator to thereby separate the two components. An optional second electrostatic separation step may be employed.

The foregoing methods do not address the significant problems that arise when attempting to process mixed waste materials in order to obtain paper fiber and/or plastic suitable for recycling to high grade end uses, such as in laminated paperboard products in which the paperboard must meet certain brightness and dirt content requirements, and in which a plastic film is laminated to paperboard. These problems are further complicated when attempting to process mixed waste materials containing metal foil to obtain paper fiber and/or plastic suitable for use in laminated products which also include a layer of metal foil.

Laminated paperboard products are found in many forms and represent a high grade end use for recycled paper fiber and plastic due to the relatively stringent quality requirements of the several components of the products.

Laminated paperboard products are used as a packaging material, particularly in the form of cartons for storing consumable liquids like juices and milk. Cartons which generally have reclosable upper ends are typically laminated products made

of paper fiber laminated on both sides with a layer of plastic such as polyethylene. This type of carton, known as a gable-top carton, is generally stored and sold refrigerated, and is typically refrigerated during use. A typical construction is a three-layer laminate having the sequential layers: polyethylene/fiber/polyethylene.

Aseptic cartons are those which are generally not intended to be reclosed. Aseptic cartons are filled under aseptic conditions, so that the liquid contents completely fill the carton and there is no air or gas above the liquid. Filling the cartons under these aseptic conditions provides a long shelf life for the contents. The packaging may include a barrier layer which prevents oxidation of the liquid contents. This type of carton is typically provided with an area that may be punctured for inserting a straw. The straw remains in the puncture hole until the contents are consumed. The most common commercial example of an aseptic carton is an individual juice container, commonly known as a "juice box". Aseptic cartons are laminated products which include both paper fiber and plastic layers as well as a thin metal foil layer, such as aluminum foil. A typical construction includes layers of polyethylene separately sandwiching layers of paper fiber and aluminum foil, to form a five layer laminate having the sequential layers: polyethylene/paperboard/polyethylene/foil/polyethylene.

The laminated paperboard products, exemplified by gable-top cartons and aseptic packages, pose particularly stringent requirements upon the various components forming the different layers of the laminates. These requirements have heretofore limited, or excluded, recycled paper fiber and/or recycled plastic from finding use in such laminates.

Specifically, the paper fiber used in these laminated paperboard products generally is required to be of high brightness and low in dirt content. Elevated dirt count can cause streaking problems during clay coating of the board and also may not be acceptable from an appearance point of view. Elevated dirt content also can cause problems in attaining

acceptable adherence between the resulting paperboard and other layers, e.g., plastic, of the laminate. Further, the paper fiber used in these laminated paperboard products must have sufficient brightness so as not to have adverse impact on the brightness of the resulting paperboard; otherwise, the resulting paperboard may not be amenable to accepting printing and/or may not be aesthetically pleasing. The board must also meet certain levels of physical strength properties, like stiffness etc.

Also specifically, the plastic used in these laminated paperboard products generally is required to be very low in contaminants as well. One of the properties required of the plastics used in these laminated paperboard products is the ability to be extruded into thin films. Contaminants in the plastic, such as residual paper fiber and/or residual metal and/or elevated moisture content (which may be due in part to moisture absorption by residual paper fibers) disrupt the film-forming ability of the plastic.

With the continuing growth of the laminated paperboard product industry, particularly for packaging of consumer goods, there is an increasing need for a process of processing mixed waste materials to obtain recycled paper fiber and/or recycled plastic which can be utilized in laminated paperboard products.

Also, because laminated paperboard products such as gable-top and aseptic cartons contain plastic and/or plastic/metal composites, they are not biodegradable. With increasing concern over the environment, there is also growing pressure to find a way to separate and recycle the components of laminated paperboard products, particularly the paper fiber and plastic portions. Preferably, a method for processing mixed waste materials should allow the recycled paper fiber and/or recycled plastic to be reused in the same or similar product from which it was derived, i.e. the so-called "carton-to-carton" recycling.

SUMMARY OF THE INVENTION

The present invention is generally directed to a method of separating paper fiber from mixed waste materials which contain one or more sources of paper fiber in order to obtain

substantially pure paper fiber. The paper fiber is preferably suitable to be recycled into laminated paperboard products.

The method in one of its broadest aspects comprises:

(a) agitating the mixed waste material in the presence of water to form a slurry comprised of a paper fiber portion and non-paper fiber portion;

(b) separating a substantial amount of the paper fiber portion from the slurry to form a paper fiber-enriched stream;

(c) treating the paper fiber-enriched stream under conditions to alternately separate heavy and light contaminants from the paper fiber-enriched stream to form a clean paper-fiber-enriched stream; and, optionally,

(d) treating the clean paper fiber-enriched stream resulting from step (c) by floatation under conditions to further remove light contaminants from the fiber-enriched stream to thereby obtain wet paper fiber.

In step (a) of the present process, the agitation generally takes place in a hydrapulper at elevated temperatures on the order of, for example, between 35°C and 75°C, preferably from 40°C to 65°C. The agitation time can vary from as little as 5 to 10 minutes to 30 to 45 minutes or longer. The temperature and agitation time generally depend upon the source of paper fiber, the nature of the mixed waste materials and the degree of agitation desired. Also during the agitation, the pH of the slurry is usually basic in nature (although this is not required), preferably ranging from about pH 9.0 to pH 12.5, and the pH can be maintained by the optional addition of a basic material such as sodium hydroxide, during the agitation. In addition, sodium hypochlorite can also be added at a level of about 20-50 ppm., in order to reduce the bacteria load in the pulper.

In step (b) of the present process, the slurry is generally passed from the hydrapulper through a coarse screen initially, followed by a slotted screen or other mechanical seive-like device so as to allow a paper fiber-enriched stream

to proceed for further processing, while retaining the paper fiber-depleted (residual) portion of the slurry.

In step (c) of the present process, the paper-fiber enriched stream is generally treated through the use of two different types of centrifugal separators to effect the alternate separation. One type of centrifugal separator (also known as a "high density" cleaner or "forward" cleaner) is suitable for removing heavy contaminants from the paper fiber-enriched stream. The other type of centrifugal separator (also known as a "reverse" cleaner) removes light contaminants from the paper fiber-enriched stream. At least one of each type of separation (i.e. at least one heavy contaminant separation and at least one light contaminant separation) is employed according to step (c) of the present process. Preferably, at least two light contaminant separation treatments ("reverse" cleaners) are employed in series in step (c) of the present process and the "reverse" cleaner or cleaners follow the "forward" cleaner in sequence.

In optional step (d) of the present process, the clean paper fiber-enriched stream resulting from step (c) is passed through one or more floatation cells which further remove light contaminants especially ink particles or dirt, from the paper fiber-enriched stream. Preferably, the floatation cell(s) immediately follow the use of the "reverse" cleaner or cleaners, regardless of whether the "reverse" cleaners precede or follow the "forward" cleaner.

The present invention is also generally directed to an apparatus for separating paper fiber from mixed waste materials which contain one or more sources of paper fiber in order to obtain substantially pure paper fiber. The apparatus in one of its broadest aspects comprises:

(a) means for agitating the mixed waste material in the presence of water to form a slurry comprised of a paper fiber portion and non-paper fiber portion;

(b) means for separating a substantial amount of the paper fiber portion from the slurry to form a paper fiber-enriched stream;

(c) means for removing heavy weight (more dense) contaminants from the paper fiber-enriched stream; and

(d) means for removing light weight (less dense) contaminants from the paper fiber-enriched stream resulting from (c) to thereby obtain a wet paper fiber pulp.

The present invention is most preferably directed to a method and apparatus of separating paper fiber from laminated paperboard products which contain at least one laminated plastic/fiber layer and which may optionally contain one or more layers of plastic laminated metal foil. These laminated paperboard products are used, for example, in the production of gable-top (milk) and aseptic (juice box) cartons for storing consumable liquids.

The method in its most preferred embodiment comprises agitating a laminated paperboard product in the presence of water to form a slurry which then becomes the feed for the later recycling steps. The laminated paperboard product may optionally be pretreated to deodorize, sanitize and/or improve the handling characteristics of the feed.

A substantial portion of the plastic derived from the laminated paperboard product is then removed from the slurry to yield the paper fiber-enriched stream, which is passed through a slotted screen and then sent to a centrifugal separator. This first centrifugal separator is also known as a "high density" cleaner or "forward" cleaner. Heavy contaminants are removed from the paper fiber-enriched stream through the bottom of the first centrifugal separator, while the paper fiber-enriched stream is removed from the overhead. This step can, optionally, be repeated. The resulting stream, having heavy contaminants removed, is then sent to a second centrifugal separator. This second centrifugal separator is also known as a "reverse" cleaner. In this reverse cleaner, light contaminants are removed

from the overhead while a recyclable paper fiber enriched stream, which is now heavier, is removed from the bottom.

Generally, in those situations where there is ink printing on the plastic portion of the laminated paperboard product, the ink printing remains with the plastic portion and is removed along with the plastic portion, in accordance with the foregoing steps.

However, if ink printing is on the paper portion of the laminated paperboard product, one or more steps will generally be needed in order to remove the ink. Generally, as the first step of the deinking, chemicals are added and air is introduced into the paper fiber-enriched stream in order to float out (as a froth) ink particles. This generally can be accomplished in a floatation tank, following the action of the reverse cleaner. A possible second step for the removal of ink from the paper portion of the laminated paperboard products is to wash out the ink with a water-wash and thereafter flush out the ink with large amounts of water as the carrier. A possible third step is to disperse the ink into very small particles by mechanical means.

The paper fiber-enriched stream following the action of the reverse cleaner, or following the action of the optional deinking stages, is a wet fiber pulp which can be recycled and used in a paper production process. The wet fiber pulp can be sent as a stream directly to a paper mill or can optionally be pressed to remove a substantial amount of water (on the order of 10-50%) and baled for later use.

The present invention also includes as an alternate embodiment, a method and apparatus for separating the plastic and/or plastic/ metal composite from mixed waste materials which contain one or more sources of plastic and/or plastic/metal composite in order to obtain substantially pure plastic, and/or in order to obtain plastic/metal composite having a high metal content, suitable for the economic recovery of the metal. The process in one of its broadest aspects comprises:

(a) shredding the mixed waste material, preferably the residual portion of the slurry from the above paper fiber

recovery process, to increase the exposed surface area of the mixed waste material;

(b) washing the shredded mixed waste material for a time and under conditions sufficient to remove a substantial portion of heavy contaminants such as paper fibers;

(c) separating the washed mixed waste material under conditions which remove residual heavy contaminants to yield a (1) plastic stream or (2) plastic and plastic/metal composite stream and proceeding to optional step (e) if (1) is present or to step (d) if (2) is present;

(d) separating the plastic and plastic/metal composite under laminar flow conditions to yield a plastic fraction and a plastic/metal composite fraction; and, optionally,

(e) treating the plastic fraction to a further separation under conditions which remove residual plastic/metal composite to yield a plastic-enriched fraction; and, optionally,

(f) treating the plastic/metal composite fraction to a further separation under conditions which remove residual plastic to yield a plastic/metal composite-enriched fraction.

The process can further include drying and pelletizing the plastic-enriched fraction to obtain substantially pure plastic suitable for use in blow molding, and preferably for use in film-forming. The process can further include drying the plastic/metal composite-enriched fraction for use in recovery of the metal therefrom.

The residual portion of the agitated mixed waste material, which is removed from the slurry in the initial stages of the above-described process and which contains plastic and/or plastic/metal composite, is first ground. Residual fiber in the ground residual portion may be removed by employing a washing step through the use of, e.g., a turbo washer. The turbo washer operates at a relatively high (1000-1500) rpm and throws off residual fiber as a mixture of fiber and water. The fiber/water mixture (of about 99% H_2O) is passed through a screen to reduce the water content (to about 90%), resulting in a paper fiber which again may be baled for further processing or used as such.

The combination of steps of the present invention for the recovery of paper fiber, when used in combination (if desired), can provide for substantially complete recovery of the paper fiber from the paper fiber sources of the mixed waste materials. Moreover, this paper fiber is substantially pure in that it is essentially free of light and heavy contaminants. This paper fiber also has substantially improved dirt content and brightness, as described above, than was heretofore believed possible to achieve.

If the residual portion of the mixed waste material, when freed of residual paper fibers, contains only plastic and does not contain any plastic/metal composite or other heavy contaminants, this plastic portion will be of suitable cleanliness to be recycled. Because of the removal of the residual fiber, this plastic portion is not limited to low end uses (as is the case in the prior art), but is suitable for use in the manufacture of, e.g., plastic films. It is thus suitable for recycling back into other laminated paperboard products.

The present invention also provides for separating the plastic portion of the hydrapulper from the plastic/metal composite which may be contained in the residual portion.

In this embodiment of the present invention, there is first employed one or more sedimentation tank(s) which, through variations in flow, causes most of the heavier contaminants, if present, to settle out, while most of the lighter plastic and plastic/metal composite flows off. This flow-off is a mixture containing essentially only the plastic portion and the plastic/metal composite. This flow-off mixture is then subjected to treatment in a sedimentation tank through laminar flow in order to separate the plastic from the plastic/metal composite. If there are no components of the residual portion from the hydrapulper other than plastic and plastic/metal composite, these can be immediately treated (after washing to remove residual paper fibers, as above) by laminar flow.

For example, in the case where gable-top and aseptic cartons are jointly being recycled, the residual portion will

contain a major portion of polyethylene (from the gable-top and aseptics), while it will contain a minor portion of polyethylene/foil/polyethylene composite (from the aseptics). This mixture can be directly treated in a sedimentation tank by laminar flow to effect a gross separation of plastic from plastic/metal composite.

The mixture is then treated in a separator (e.g., a "forward" cleaner) to remove a substantial amount of the plastic/metal composite to obtain relatively a relatively pure plastic portion. This may be repeated, as necessary, to reduce the metal content. The resulting suspension is thereafter passed through a series of drying stages, the first one of which can include a screw press to obtain a substantially pure dry plastic. The dry plastic is then pulverized, passed through an extruder and a continuous screen changer, typically having a fine size, such as < 100 μm (to remove residual contaminants, including large pieces of metal foil) and pelletized. The pelletized plastic portion which results is now of sufficient purity to be used as is or mixed with virgin plastic, and can be used in laminated paperboard products.

The plastic/metal composite can be treated to recover the metal therefrom.

In accordance with the most preferred embodiment of the present invention, each of the major components of a laminated paperboard material (including paper fiber, plastic and plastic/metal composite) is separated and recovered. The recovered materials can be recycled and used to manufacture the original product, such as gable-top and aseptic cartons or, in the case of the plastic/metal composite, can be treated to recover the metal using pyrolysis.

BRIEF DESCRIPTION OF THE DRAWINGS

The following drawings are illustrative of embodiments of the invention and are not intended to limit the invention as encompassed by the claims forming part of the application.

Figure 1 is a schematic view of one embodiment of the invention for separating the paper fiber from mixed waste materials and recovering substantially pure paper fiber; and

Figure 2 is a schematic view of another embodiment of the invention in which a combination of the plastic and plastic/metal composite are treated to recover plastic and paper fiber of substantially pure, recyclable quality (by which is meant that the plastic portion can be used in film-forming applications, and the paper fiber is recyclable into high quality end uses). Also, the plastic/metal composite which is recovered contains sufficiently high amounts of metal (e.g., $>20\%$ in the case of aluminum) so as to be suitable for use in processes for recovery of the metal.

DETAILED DESCRIPTION OF THE INVENTION

The present invention is directed to a method and apparatus for separating the paper fiber and plastic and/or plastic/metal composites from mixed waste materials and, preferably, from laminated paperboard products. The paper fiber, and preferably the plastic and plastic/metal composite components of the mixed waste material, is recovered in a condition suitable for recycling into laminated paperboard product or for the economical recovery of the metal.

As mentioned above, the mixed waste materials which contain one or more sources of paper fiber include newspapers, magazines, cardboard, beverage containers, such as milk cartons and/or aseptic packages, or combinations of the foregoing.

One measurement of dirt count in resulting paperboard products are the TAPPI dirt count. The TAPPI dirt count is a measure of the area of dirt for a given paperboard area. Higher TAPPI dirt count corresponds to a board with more specks.

The TAPPI dirt count (mm^2/m^2) for a paperboard product containing 30% of recycled paper fiber obtained according to the process of the present invention is generally less than about 100, preferably less than about 80, more preferably less than about 40, and most preferably less than about 20. For a paperboard product containing about 10% of recycled paper fiber obtained according to the process of the present invention, the TAPPI dirt count is generally less than about 40, preferably less than about 30, more preferably less than about 20, and most preferably less than about 10.

The brightness of paperboard product containing 15% of recycled paper fiber obtained according to the process of the present invention is generally above 80, preferably above 80.5, and more preferably above 81. The recycled paper fiber obtained according to the present process generally has a brightness of greater than about 78, preferably equal to or greater than about 80.

Laminated paperboard products which are used in the manufacture of gable-top and aseptic cartons contain a layer of paper fiber sandwiched between layers of plastic such as polyethylene. If a metal foil layer is present, which is generally the case in aseptic cartons, it too is sandwiched between layers of plastic, such as polyethylene.

The feed of the method and apparatus of the present invention can be any mixed waste material containing one or more sources of paper fiber, or can be factory or consumer waste and can also contain one or more sources of plastic and/or plastic/metal composite.

Generally, the recovery of paper fiber from a feed of laminated paperboard products (or from feeds comprising other plastics such as plastic/metal composites, e.g. yoghurt containers) poses peculiar problems in that the paper fiber is subject to contamination by particulate plastic and/or metallic matter.

The figures will be discussed in terms of recovery of paper fiber from a mixed waste material feed containing a source

of paper fiber such as newspaper, and laminated paperboard products.

Referring to Figure 1, there is shown an embodiment of the invention for separating the paper fiber component from the plastic and/or plastic/metal composites. The separation system 2 commences when a feed containing source of paper fiber (such as newspaper) and containing a laminated paperboard product (such as aseptic containers), is sent to a hydrapulper 4 where it is agitated in the presence of water to form a slurry. The feed may optionally be pretreated (such as to remove odor, bacteria and the like). Pretreatment may also include first shredding the feed and then rinsing the shredded feed in water to remove odoriferous materials as well as to soften the feed. Thereafter, the softened feed may be baled and/or treated with a bleaching agent prior to entry into the hydrapulper 4. The hydrapulper 4 contains an agitator 6 which frees the mixed waste material of paper fiber and which also delaminates the laminated paperboard product and facilitates separation of paper fiber from the plastic and/or plastic/metal composite thereof through an extraction plate 7 at the bottom of the pulper 4.

During treatment in the hydrapulper 4, a chemical agent (such as sodium hydroxide or sodium hypochlorite) may be added to maintain the pH, deodorize, sanitize, bleach and/or improve the handling characteristics of the feed.

The hydrapulping process is conducted at a temperature of about 35°C to 75°C, preferably from about 50°C to 65°C at a residence time which typically varies from about 5 to 45 minutes, preferably from 15 to 30 minutes. A residence time at the low end of the range (e.g., 5 to 15 minutes) is preferred for mixed waste materials containing predominantly newspapers and magazines, at the middle of the range (e.g., 15 to 30 minutes) for mixed waste materials predominantly containing cardboard boxes and mixed waste, and at the high end of the range (e.g., 30 to 45 minutes) for mixed waste materials containing predominantly laminated paperboard products (e.g., gable-tops and aseptics). The hydrapulping process is also conducted in a basic

environment in which the pH is in the range of about 8.0 to 10.0.

The resulting slurry is passed via the line 8 through a coarse screen 9 followed by a slotted screen 10 (such as a Model 12 PH/PS pressure screen) which separates the paper fiber component from the residual component, i.e., the plastic and/or plastic/metal composite into a paper fiber stream and a residual stream. The residual stream is removed from the system 2 via the line 8 and may be combined with the stream obtained via the line 12 for further treatment as described hereinafter. The dimensions of the slots in the screen 10 may be adjusted to screen out contaminants while allowing the fibers to undergo further processing. Preferably, the slots are on the order of .004" to .010", more preferably on the order of about .006".

Referring again to Figure 1, the paper fiber stream (containing over 99% water) is transported from the slotted screen 10 via the line 14 to a portion of the separation system 16 which includes first and second centrifugal separators 18, 20. The separators 18, 20 are cleaners which separate the feed into high and low density fractions. The high density fraction is removed from the bottom, while the low density fraction is extracted from the overhead. In accordance with the embodiment depicted in Figure 1, the paper fiber stream is removed from the first centrifugal separator 18 as the overhead and from the second centrifugal separator 20 as the bottom.

More specifically, the paper fiber stream containing a major amount of paper fiber portion and a minor amount of residual portion is passed into the first centrifugal separator 18 (such as a 5" Ultra Clone Cleaner). Heavier contaminants are removed from the bottom of the separator 18 via the line 22. The overhead of the separator 18 contains a major amount of the paper fiber portion and a minor amount of light contaminants (and is substantially free of heavier contaminants) comprised primarily of residual plastic and ink. The overhead paper fiber-enriched stream is removed via the line 24 and sent to the second centrifugal separator 20.

The driving force which enables the paper fiber portion of the feed to pass from the first separator 18 to the second separator 20 results from a pressure drop which is maintained between line 14 and line 24 leading to the separator 20. The difference in pressure is maintained on the order of about 10 to 30 psi, and preferably about 20 psi.

The paper fiber-enriched stream then enters the separator 20 (such as a 3" X-Clone Through Flow Cleaner or Gyroclean) which is a horizontally arranged rotating, light contaminant cleaner. There is also a pressure drop maintained across the separator of about 10 to 20 psi, preferably about 15 psi. The overhead, containing lightweight contaminants (such as plastic alone or with ink), is removed via the line 26 and discarded or further treated. A substantially clean paper fiber-enriched stream is removed from the bottom of the separator 20 via the line 28.

The paper fiber-enriched stream may be treated in the separation system 16 more than once, as needed or desired, depending on the end use of the paper fiber. If the paper fiber is imprinted with ink, then a de-inking process may be used to remove an additional amount of the ink before the water is removed from the clean paper fiber-enriched stream. The de-inking process, if used, includes, preferably three steps.

As shown in Figure 1, the clean paper fiber-enriched stream is sent via the line 28 to a floatation tank 30 where compressed air is introduced via the line 32 creating a froth in which the ink particles are separated from the paper fiber. Because the ink is lighter than the paper fiber, it floats as a froth on the top of the clean paper fiber-enriched stream which is removed from the tank 30 via the line 34. The de-inked, clean paper fiber-enriched stream is then washed with water and thickened in a tank 36, and is thereafter treated in a dispersing tank 38 with a dispersing agent to reduce the size of the ink particles which are removed from the system.

The de-inked, clean paper fiber-enriched stream is passed via the line 40 directly to a paper mill or is pressed in

a compressor 42 to remove a substantial amount of water (from 30 to 50%) and then baled for shipment to a paper mill.

The resulting paper fiber is of high cleanliness and brightness and can be used directly to make new laminated paperboard products such as gable-top and aseptic cartons. Moreover, the quality of the resulting paper fiber allows the use of greater amounts of recycled paper fiber in the production of new paperboard. Illustratively, the process of the present invention results in a paper fiber of sufficiently high quality to permit the use of at least 15%, preferably at least 20%, more preferably at least 25%, and most preferably at least 30% recycled paper fiber in new paperboard. The resulting paperboard has high brightness and low dirt contents comparable to paperboard made from all virgin fiber.

In accordance with another embodiment of the present invention, the residual stream which is removed via the line 12, is further processed to separate residual paper fiber therefrom.

In accordance with still an additional embodiment of the present invention, the plastic and/or plastic/metal composite is separated from the residual stream and the plastic is separated from the plastic/metal composite. As a result, there is obtained a substantially pure plastic portion suitable for use in film-forming applications, and there is also obtained plastic/metal composite (e.g., plastic/aluminum foil composite) having sufficiently high amounts of metal (e.g., › 20% in the case of aluminum) suitable for economic recovery by, e.g., aluminum processors. Substantially all of the components of the mixed waste material can therefore be recycled to high grade end uses. The paper fiber and plastic can be recycled to, e.g., a laminated paperboard manufacturing product, and the plastic/metal composite can be recycled to obtain the metal component. The recycled plastic (e.g., polyethylene) which is used as part of the laminated paperboard product is classified by its mechanical and chemical properties, and by its purity. If the recycled plastic is contaminated with impurities, such as paper fiber or metal, e.g., aluminum, in excess of about 1%, the

screening system of an extruder used to pelletize the recycled plastic will quickly plug, resulting in reduced productivity. Also, in the production of plastic films, more than 1% paper fiber in the plastic results in, inter alia, increased hygroscopy of the plastic and more than 1% of metal in the plastic results in, inter alia, "lace curtains" during film-forming. Therefore, any plastic which is considered for recycling must be substantially pure (i.e. substantially free of paper fiber and metal, i.e., having < 1% content), even though the recycled plastic typically is mixed with virgin plastic.

Referring to Figure 2, the residual stream containing plastic/foil/fiber (and other heavy contaminants) composite obtained from the line 12 is forwarded to a grinder 52 which reduces the size of the particles of the residual stream, preferably within the range of 20 mm x 20 mm to 10 mm x 10 mm or smaller. The grinder is a conventional device.

The residual stream composite is generally ground due to the curled and twisted shape of the majority of the plastic and/or plastic/metal composite of the residual stream. To efficiently remove the residual paper fiber, the residual stream composite is shred or ground into smaller pieces on the order of about 10 mm.

The ground residual stream composite is sent via a line 54 to a mechanical agitation device 56 which separates residual paper fiber from the remaining (if any) heavy contaminants and the plastic and/or plastic/metal composite of the residual stream. The device 56 may be a hydrapulper such as described in connection with Figure 1, or a combination of a floatation tank and cyclone separator. In Figure 2, the separation is carried out by a turbowasher operating at 1,000-1,500 rpm in conjunction with a basket screen with holes on the order of 2-5 mm, allowing the residual fiber stream to pass through and retaining the remaining (if any) heavy contaminants and the plastic and/or plastic/metal composite portion of the residual stream, which produces a residual paper fiber stream containing about 99% water. The residual paper fiber stream passes via the line 58

through a screen assembly 60 which removes residual heavy contaminants and reduces the water content to about 90%. The fiber thus recovered can be added back to the hydrapulping process to further clean and remove plastic contaminants or used as such.

The washed residual stream containing the remaining heavy contaminants and plastic and/or plastic/metal composite, generally contains predominantly free plastic, as well as a smaller amount of the plastic/metal composite, and possibly other residual heavy contaminants (such as paper fibers) which still remain. The washed residual stream is forwarded as a stream via a line 62 to one or more sedimentation tanks 64. One sedimentation tank may suffice for the preparation of free plastic from the plastic/metal composite if the washed residual stream is substantially free of other heavy contaminants. However, in practice, it may be beneficial to employ a series of, e.g., two sedimentation tanks 64. The first serves to remove substantially all of the heavy contaminants (other than plastic/metal composites) which remain in the washed residual stream; this results in a stream exiting the first sedimentation tank which is comprised of substantially only a combination of free plastic and plastic/metal composite. The second sedimentation tanks is thus used to separate the free plastic (less dense) from the plastic/metal composite (more dense). This results, with the further processing described below, in a recycled free plastic portion which is suitable for film-forming applications and a recycled plastic/metal composite with sufficiently high metal content (e.g., › 20% in the case of aluminum) to make recovery of the metal economically fleasible.

In the first sedimentation tank (if two are used), the flow can be more turbulent than in the second sedimentation tank. This takes advantage of the greater differential in density of the heavier contaminants (on the order of 1.5 kg/m^3) as compared to plastic (0.92 kg/m^3 for low density polyethylene) and plastic/ metal composites (about 1.06-1.09 (calculated theoretical) for polyethylene/aluminum foil laminates). Those skilled in the art

can determine appropriate flows to effect separation based on density differentials without due experimentation.

The stream entering the second sedimentation tank 64, if two are used, is caused to undergo a substantially laminar flow so that the less dense free plastic separates from the heavier plastic/metal composite. The use of the laminar flow sedimentation tank 64, either alone or as the second sedimentation tank, results in a recycled plastic which allows for the use of more than double the amount of recycled plastic to be incorporated with virgin plastic, as compared to recycled plastic resulting from processes in which the sedimentation tank is not employed.

The overflow from the sedimentation tank 64, containing a major amount of the free plastic portion and a minor amount of the plastic/metal composite, is transported via the line 66 to a centrifugal separator 68 of the same or similar type as the first centrifugal separator 18 described in connection with Figure 1.

In operation, the separator 68 produces a less dense fraction, comprised primarily of free plastic portion and having a very small amount of plastic/metal composite, and a more dense fraction which is removed from the bottom of the separator 68 via the line 70. The more dense fraction contains a predominant amount of the plastic/metal composite which may be further processed to recover the metal and/or plastic therefrom.

In practice, a plastic and plastic/metal composite feed to a laminar flow sedimentation tank comprising about 94.6% polyethylene and about 5.4% aluminum yields a sedimentation fraction (aluminum fraction) comprised of 80.5% polyethylene and 19.5% aluminum and an off-flow fraction (polyethylene fraction) comprised of 95.9% polyethylene and 4.1% aluminum.

The aluminum fraction is passed through two separators in series within the bottoms from the first separator (enriched aluminum fraction) being passed to the second separator. The bottom from the second separator is comprised of about 78.8% polyethylene and about 21.2% aluminum, sufficient to allow

economical recovery of the aluminum. Further separators will lead to higher aluminum content, and the use of only one separator may suffice in a particular application.

The polyethylene fraction is passed through two separators in series with the overhead from the first separator (enriched polyethylene fraction) being passed to the second separator. The overhead of the second separator is comprised of about 97.8% polyethylene and about 2.2% aluminum. Further separators can be used to reduce the aluminum content to at or below about 1%, and the use of one separator may suffice in a particular application. The amount of residual aluminum may also be reduced directly by the extrusion of the enriched polyethylene fraction, as described below.

The bulk of the plastic/metal composite, including the bottoms from the separator 68, may be treated in a conventional manner to recover the metal or the plastic. The residual water content after drying should be less than 1%. For example, the plastic/metal composite may be pyrolyzed under environmentally controlled conditions to recover the metal foil. Alternatively, the plastic/metal composite may, for example, be reacted with a suitable solvent to dissolve the plastic and recover the metal and plastic.

The plastic is transported via the line 72 to a drying system 74. In the embodiment shown in Figure 2, the drying system 74 includes a vibrating screen 76, a screw press 78 and a hot air dryer 80 to remove a substantial amount of the water from the free plastic. The residual water content after drying should be less than 1%.

A rotating drum pulverizer 82 may be used to substantially pulverize the dry material into dust after the plastic has been dried in the hot air dryer 80. The dust then melts by friction and is passed into an extruder 86. As it is extruded, the material is passed through a continuous screen 88 which removes large pieces of residual contaminants and metal.

Thereafter, the substantially pure plastic can be pelletized in a customary manner and combined with virgin plastic

in a weight ratio of from 1:4 to 2:5 (recycled:virgin) for use in making the laminated paperboard product.

In accordance with the present invention, the processing steps described herein can be modified to obtain a higher quality product within the spirit and scope of the invention.

CLAIMS

1. A method of separating paper fiber from mixed waste materials which contain sources of paper fiber, plastic with or without metal, said method including agitating the mixed waste materials in the presence of water in a hydrapulper to form a slurry comprised of a paper-fiber portion and a plastic and metal portion, characterized by extracting water and plastic and any metal and a substantial amount of the paper-fiber portion from the slurry out of the hydrapulper to form a liquid stream; removing plastic and any metal from the liquid stream to produce a paper fiber-enriched stream; and subsequently removing light contaminants from the fiber-enriched stream to thereby obtain wet paper fiber.

2. The method as claimed in Claim 1, wherein the paper fiber-enriched stream is first treated in a first centrifugal separator to separate heavy contaminants from the paper fiber-enriched stream and then treated in a second centrifugal separator to separate light contaminants from the paper fiber-enriched stream.

3. The method according to Claim 1 or 2, including the additional step of passing the paper fiber-enriched stream through a flotation tank for separating ink particles from the paper fiber-enriched stream prior to the compressing step.

4. The method of Claim 1, wherein removing plastic and any metal from the liquid stream is accomplished by

passing the stream in sequence through a coarse screen and a slotted screen.

5. The method of Claim 1, including transferring the removed plastic and metal components to a grinder; grinding the plastic and metal components in the grinder; separating plastic components from metal components after the grinding step; drying plastic components from the separating step; supplying the dried plastic components to an extruder; and extruding the plastic components.

6. The method according to Claim 5 wherein said separating step includes supplying the plastic and metal components to a sedimentation tank to allow the more dense components to settle out and the plastic components to be removed with the water stream.

7. The method according to Claim 5 including pulverizing the dried plastic components before supplying the plastic components to said extruder.

8. The method as claimed in Claim 2 including maintaining a pressure differential between said first separator and said second separator of between about 10 and 30 psi to cause flow from the first separator to the second separator.

9. The method as claimed in Claim 4 wherein said slotted screen has slots between about .004 and .010 inches in width and the fiber-enriched stream passing out of the slotted screen contains at least 99% water.

10. Recycled paper fiber produced according to the method of Claim 1.

11. Paperboard containing between about 10% and about 30% recycled paper fiber produced according to the method of Claim 1 and having a TAPPI dirt content of less than about 80.

12. Apparatus for performing the method of claim 1, said apparatus including a chamber for agitating the mixed waste material in the presence of water to form a slurry comprised of a paper fiber portion and a non-paper fiber solids portion; an extraction arrangement for separating a substantial amount of the paper fiber portion from the slurry to form a paper fiber-enriched stream; a conduit for conducting said stream from said extraction arrangement to a pulp discharge outlet; screens between said outlet and said extraction arrangement for separating paper fibers from plastic and metal components in said stream; a first centrifugal separator between said screens and said discharge outlet for removing heavy weight contaminants from the paper fiber-enriched stream; and a second centrifugal separator between said first centrifugal

separator and said discharge outlet for removing light weight contaminants from the paper fiber-enriched stream to thereby obtain a wet paper fiber pulp.

13. The apparatus according to Claim 12, including a transfer arrangement for transferring plastic and metal components from the chamber and from the screen to a grinder station; a grinder for grinding said components at the grinder station; a plastic extruder for extruding the plastic, the transfer arrangement including apparatus to transfer said components from said grinder to the extruder.

14. The apparatus according to Claim 13 including pulverizer means for pulverizing plastic and metal components before being transferred to the extruder.

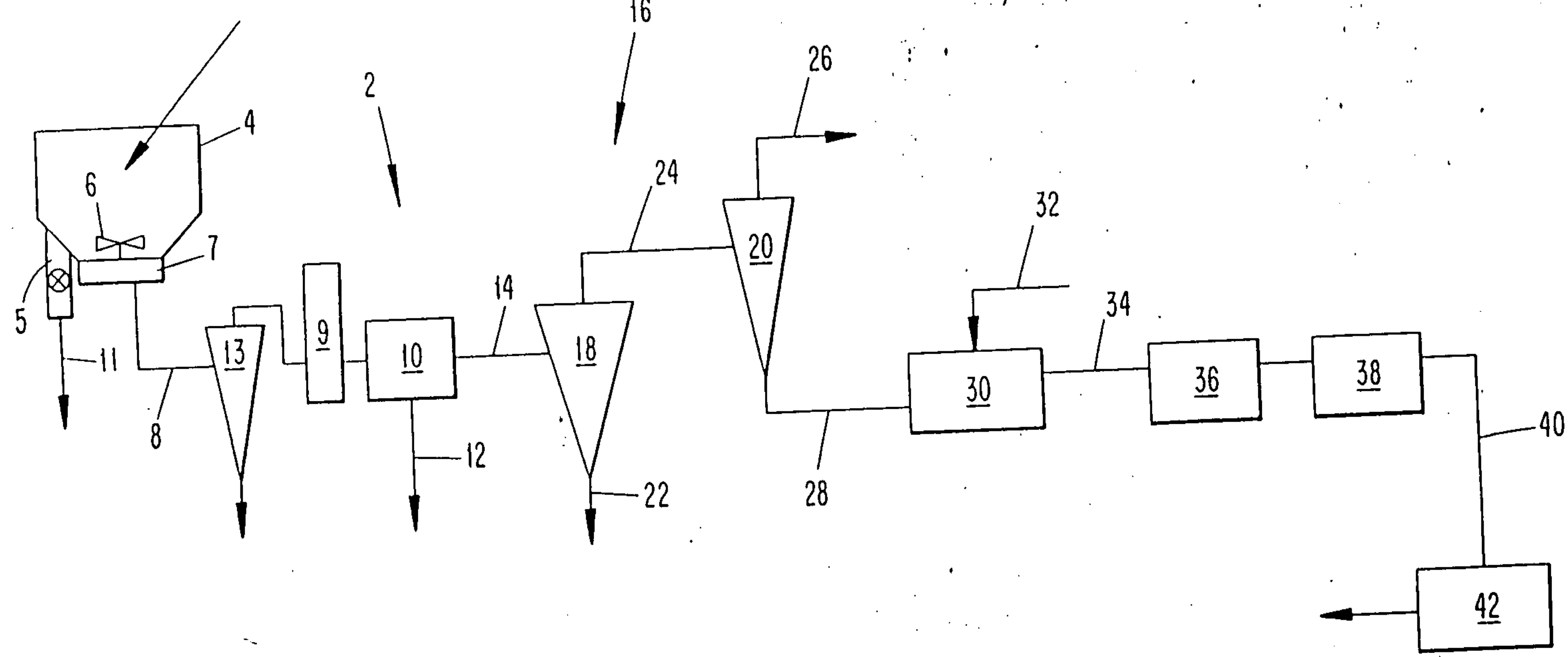
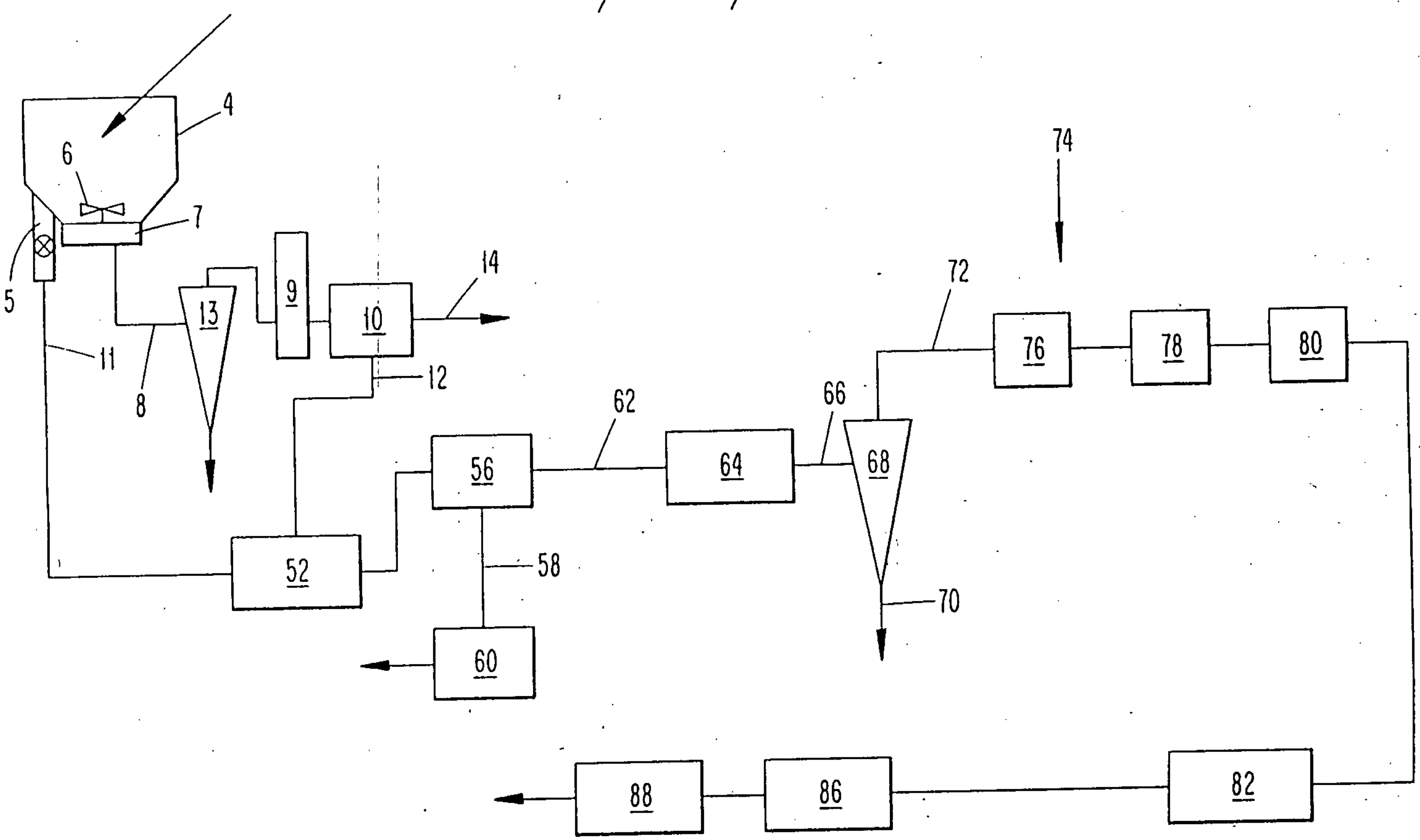


Fig. 1

Fig. 2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